



Implementing End-use Efficiency Improvements in India: Drawing from Experience in the US and Other Countries

Jayant A. Sathaye
Senior Staff Scientist and
Head, International Energy Studies
Lawrence Berkeley National Laboratory
Berkeley, CA

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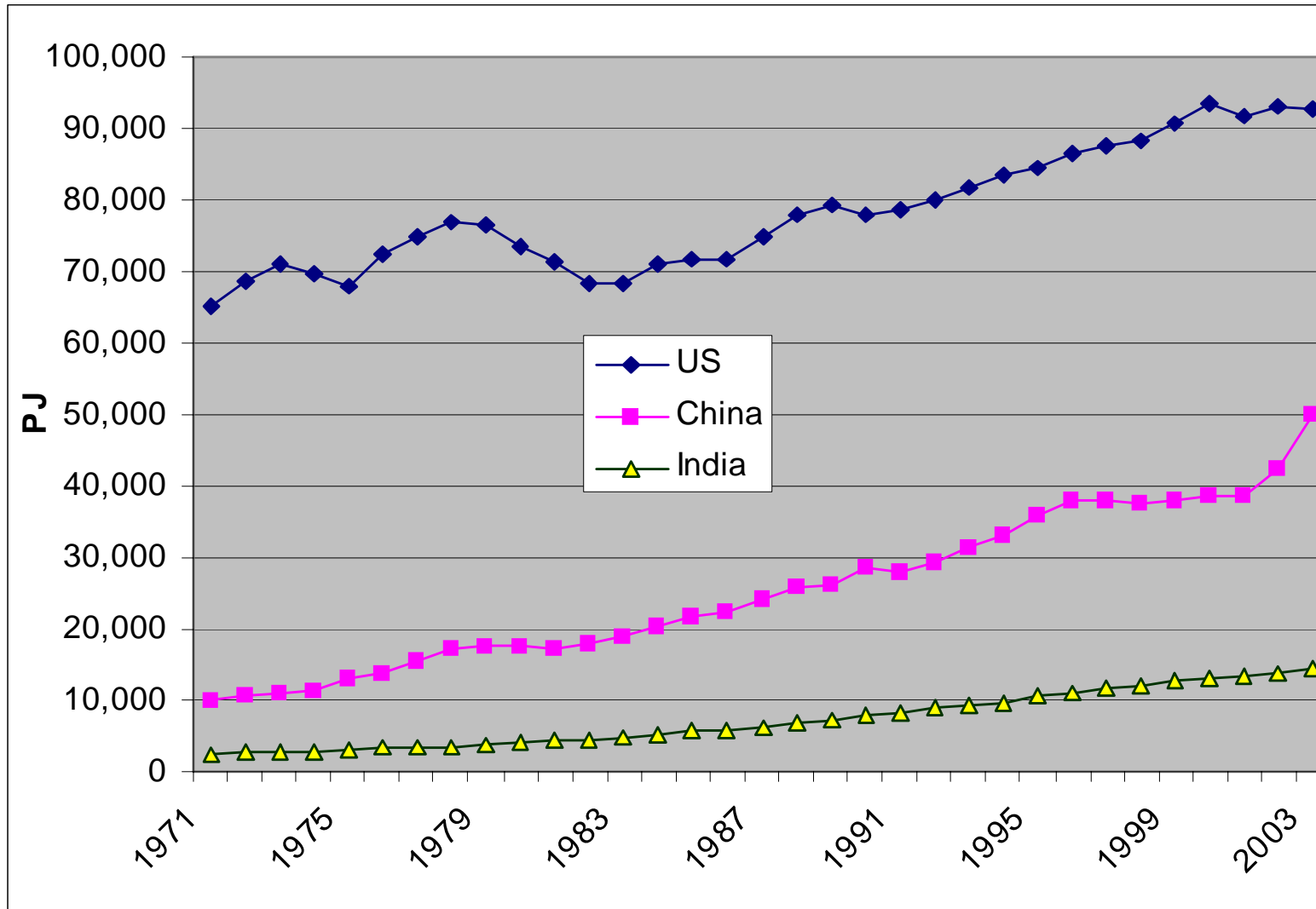


1. Energy indicators in China, India, and the US: An overview
2. Techno-economic analysis, quantification of barriers, and valuation of benefits to stakeholders
3. Buildings and appliances energy efficiency programs
4. Industrial sector energy efficiency programs
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Energy Indicators in China, India, and the US: An Overview

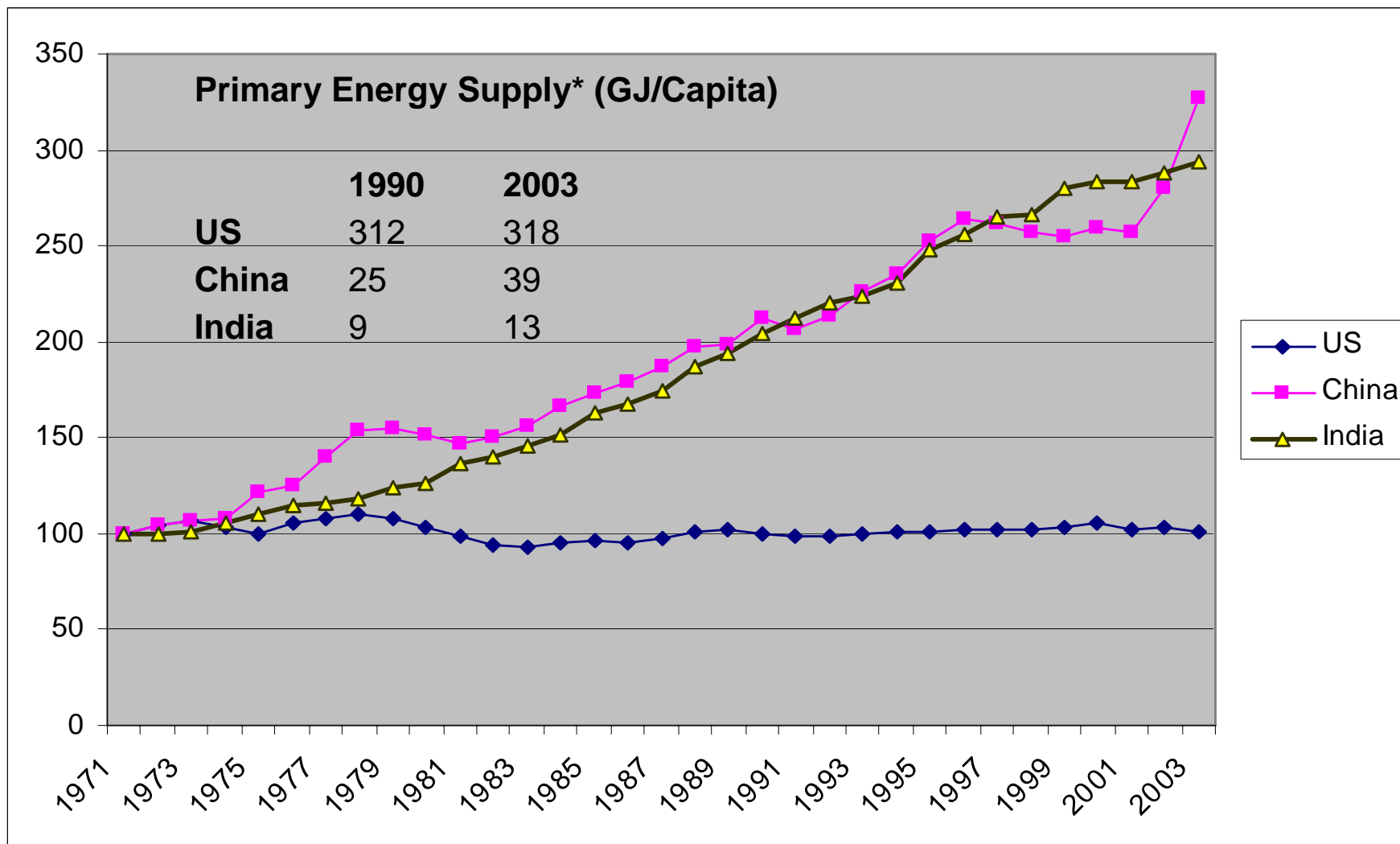
Primary Energy Supply*



* Excl. traditional biomass in India

Source: Energy data – IEA

Primary Energy Supply*/Capita (Indexed to 1971=100)

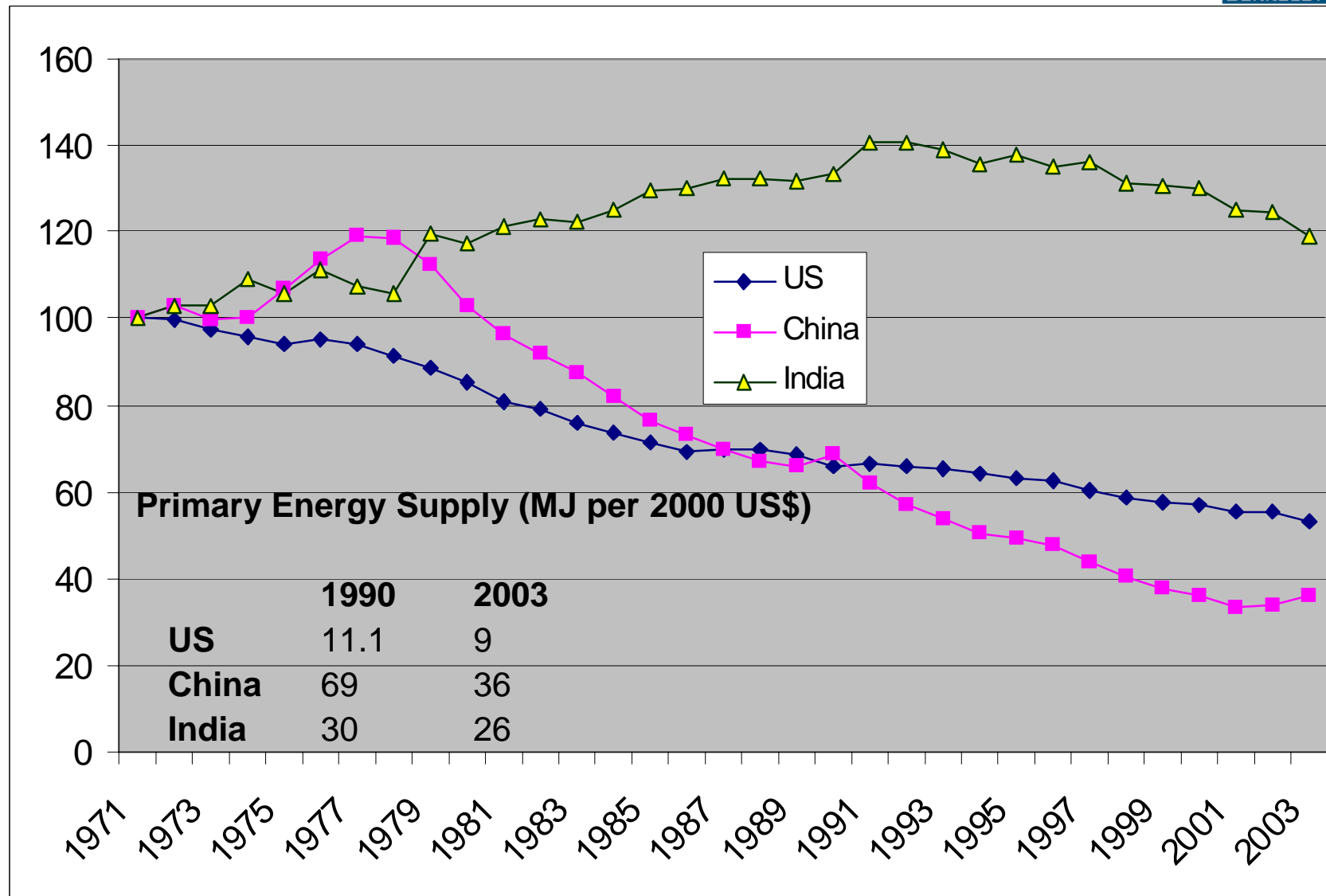


* Excl. traditional biomass in India

Source:

Energy data – IEA; Economic data – World Bank

Primary Energy Supply* / GDP (Indexed to 1971)



* Excl. traditional biomass in India

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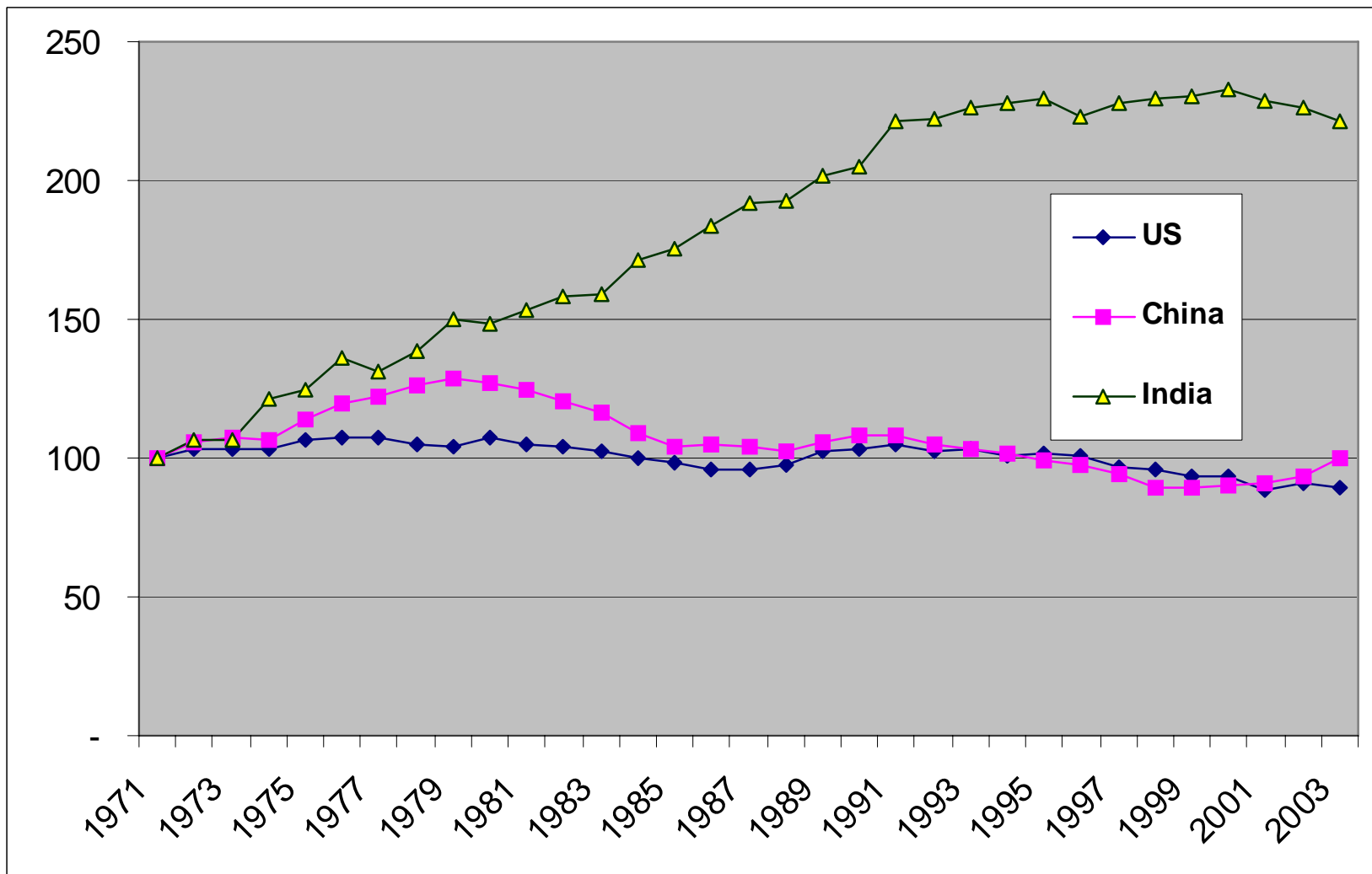
Source:

Energy data – IEA; Economic data – World Bank

India's Electricity Intensity Trend

Stabilized Beginning in 1993

(Elec. Gen./GDP; kWh/2000 US \$; Index 1971=100)



Source: Energy data – IEA; Economic data – World Bank

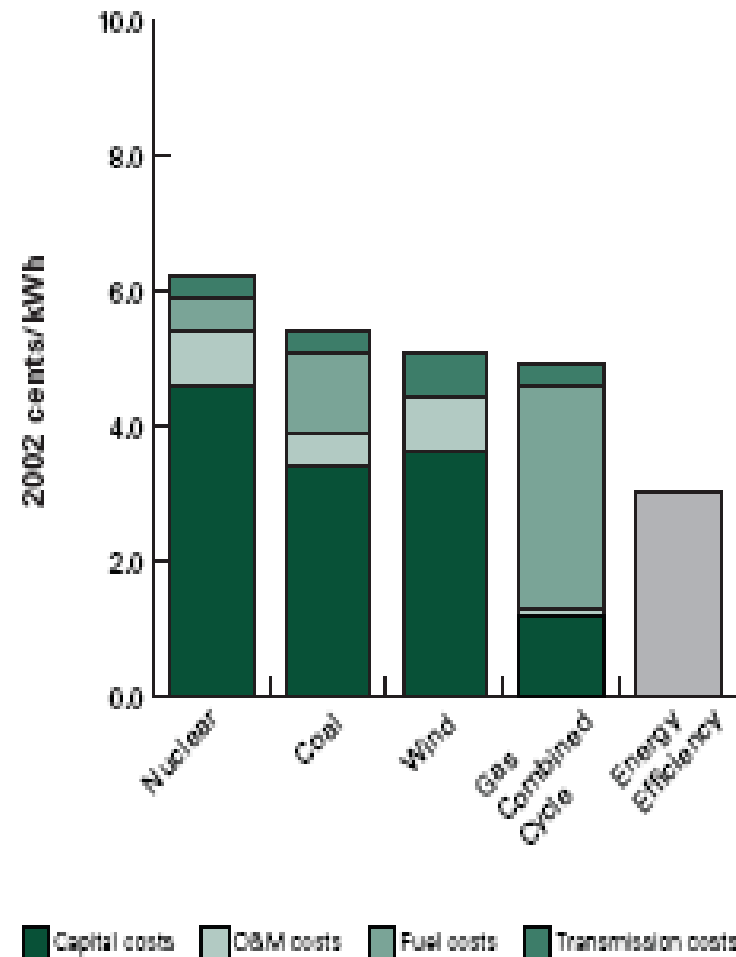


Techno-economic Analysis, Quantification of Barriers, and Valuation of Benefits to Stakeholders

Most energy efficiency technologies are cost-effective when compared with new supply options



Energy efficiency is competitive with generation technologies in US



Significant Cost-Effective Potential Exists for Improving Energy Efficiency of Products in India



Product	Base Case (kWh/year)	Efficiency Case (kWh/year)	Percentage Improvement
Refrigerator			
Direct-cool	381	208	45%
Frost-free	930	508	45%
Room air conditioner			
Window4	1191	1056	11%
Motors			
Agricultural – 5 HP	992 ²	875	12%
Industrial – 15 HP	4079	3264	20%
Industrial – 20 HP	5562	3387	39%
Distribution transformers			
25 kVA	1036	441	57%
63 kVA	1834	797	57%
100 kVA	2619	1068	59%
160 kVA	3757	1653	56%
200 kVA	4989	1880	62%

Identify Energy Efficiency Beneficiaries and Quantify Benefits



- Consumer benefits, if
 - Improving efficiency costs less than the marginal electricity tariff or energy price
- Utility company benefits, if
 - Tariff is lower than avoided cost of electricity supply, and/or
 - EE agricultural pump improvements costs less than MSEB fuel and O&M costs
 - Saved electricity can be resold to higher tariff customers
- Country and government benefit due to
 - More productive use of capital through investment in energy efficiency - less expensive than building new supply capacity
 - Where electricity supply is short, redirected supply can increase industrial and commercial output, and lower subsidy payments
 - More efficient use of capital and increased economic output leads to more jobs and increased government tax revenue
 - Maharashtra government loses sales tax worth Rs. 9 per kWh of electricity not supplied to business customers

Many Barriers Prevent the Market Penetration of Technologies



- Commonly experienced barriers across countries
 - Prices, financing, international trade, market structure, institutions, the provision of information and social, cultural and behavioral factors
- Programs are needed to overcome barriers
- Quantification of barriers, e.g., Principal Agent (PA) problems, helps improve the justification for programs
 - PA problem dampens a price signal
 - In the US for example, principal agent (PA) problem affects 79% of water heater, 28% of refrigerator, and 47% of space heating energy consumption in the residential sector



Buildings and Appliances Energy Efficiency Programs

India Energy Efficiency: Legislation, Institutions, Policies and Programs



- Federal institutions created in the 1970s and 1980s
 - Petroleum Conservation and Research Association (PCRA) under the Ministry of Petroleum and Natural Gas in 1978
 - National Productivity Council and the Energy Management Center
- Recent legislative mandates –
 - Energy Conservation Act 2001
 - Created the Bureau of Energy Efficiency (BEE) under the federal Ministry of Power to
 - Develop policies and strategies for reducing energy intensity
 - Delegate authority to state energy development agencies
 - Develop standards and labels for refrigerators, air conditioners, motors, agricultural pumps, and distribution transformers
 - Electricity Act 2003
 - Sets up central and state-level independent regulatory commissions similar to those in the US, can mandate and finance DSM programs
- Industry initiatives
 - Indian Green Business Center (GBC), Confederation of Indian Industry (CII)
 - Provides technical assistance and training to businesses

Buildings Energy Efficiency Programs



- Categories of building energy programs
 - Voluntary programs, building and appliance efficiency standards and labels, information programs, best-practice and benchmarking programs, state market transformation programs, financing, and procurement
- In the US, the federal government, and some state governments, utility companies, and regulatory commissions are key players in program development, design and implementation

Examples of Four Types of State-level Energy Efficiency Programs



- Energy Efficiency Portfolio Standards (EEPS) in 21 states
 - Targets between 10% to 50% reduction in energy demand growth
- Public Benefits Funds (PBFs) in 17 states
 - PBFs are being used to implement demand-side management (DSM) programs
 - Small non-bypassable per kWh charge on the electricity distribution service
 - Cost between 2.3 to 4.4 cents per kWh
 - Shaved 0.4% off annual electricity growth in circa 2003
- Energy Efficiency Building Codes in effect in 40 states
 - Potential to avoid 12,800 MW of new power by 2020
 - As in many countries enforcement will be a key challenge
- State Appliance Efficiency Standards
 - Apply to products not covered by Federal standards
 - In New England, for example, a package of state standards is expected to reduce load growth by 14% from 2008 to 2013 and cut summer peak demand growth by 33%

Demand-side Management (DSM) Programs Can Play a Key Role



- Indian states face several challenges —
 - Growing electricity shortage, deteriorated utility financial condition, and state fiscal deficits
- Improving electricity efficiency through DSM programs can
 - Reduce electricity shortage, a national potential of about 10,000 MW
 - Improve utility revenues and financial position
 - Reduce state government subsidy and increase sales tax revenue
 - Rs. 9 (20 cents) sales tax is lost for each kWh not delivered to businesses in Maharashtra
 - DSM has the potential to eliminate between 15-25% of state fiscal deficit

Examples of Federal-Level Energy Efficiency Programs

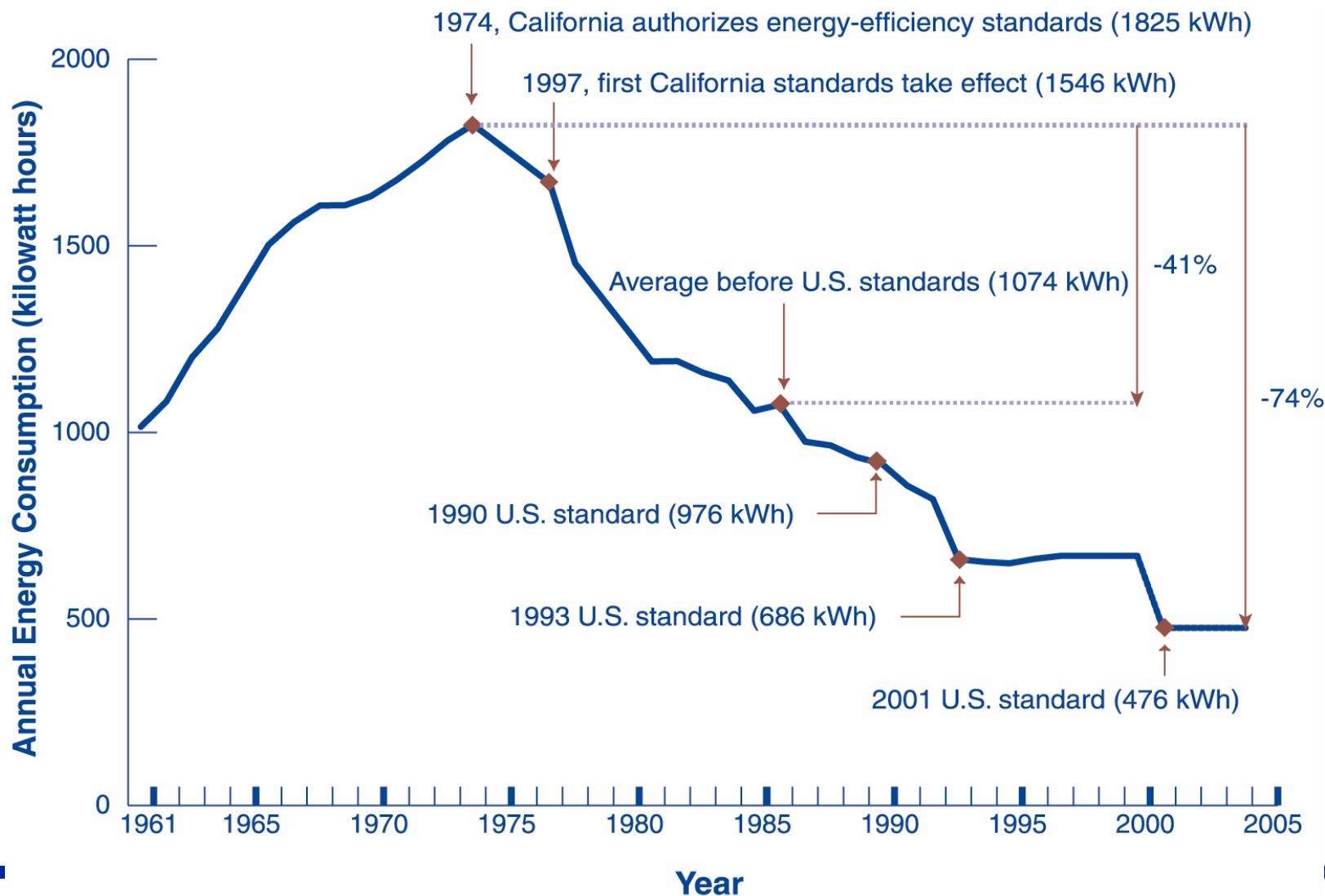


- Mandatory and voluntary standards and labels: In about 60 developed and developing countries, including the US, more than 40 household appliances are subject to federal mandatory and/or voluntary energy performance standards



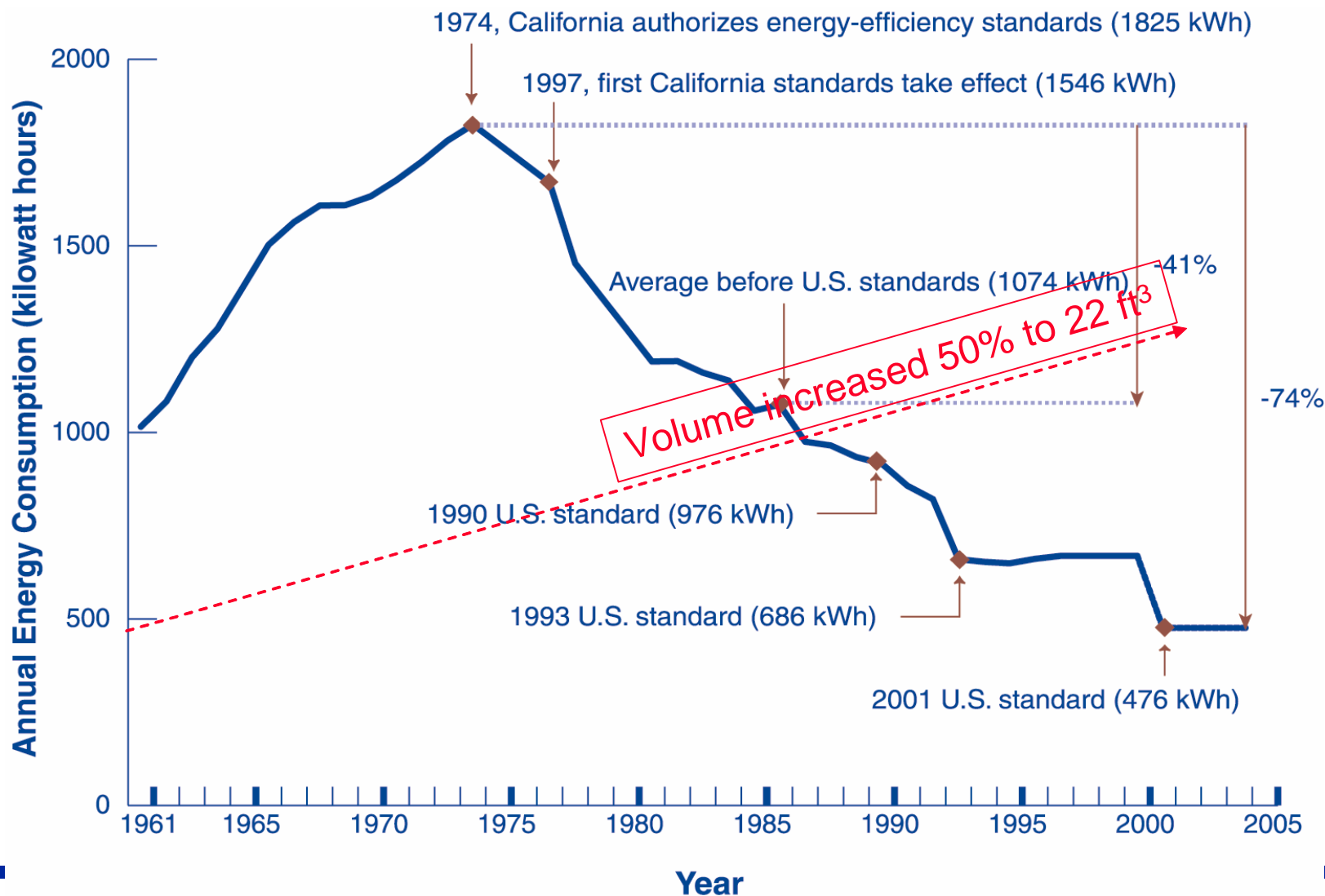
Appliance Standards and Labels Improve Energy Efficiency Dramatically

Average Energy Consumption of New Refrigerators in the U.S.



Appliance Standards and Labels Improve Energy Efficiency Dramatically

Average Energy Consumption of New Refrigerators in the U.S.



Examples of Federal-Level Energy Efficiency Programs (Contd.)

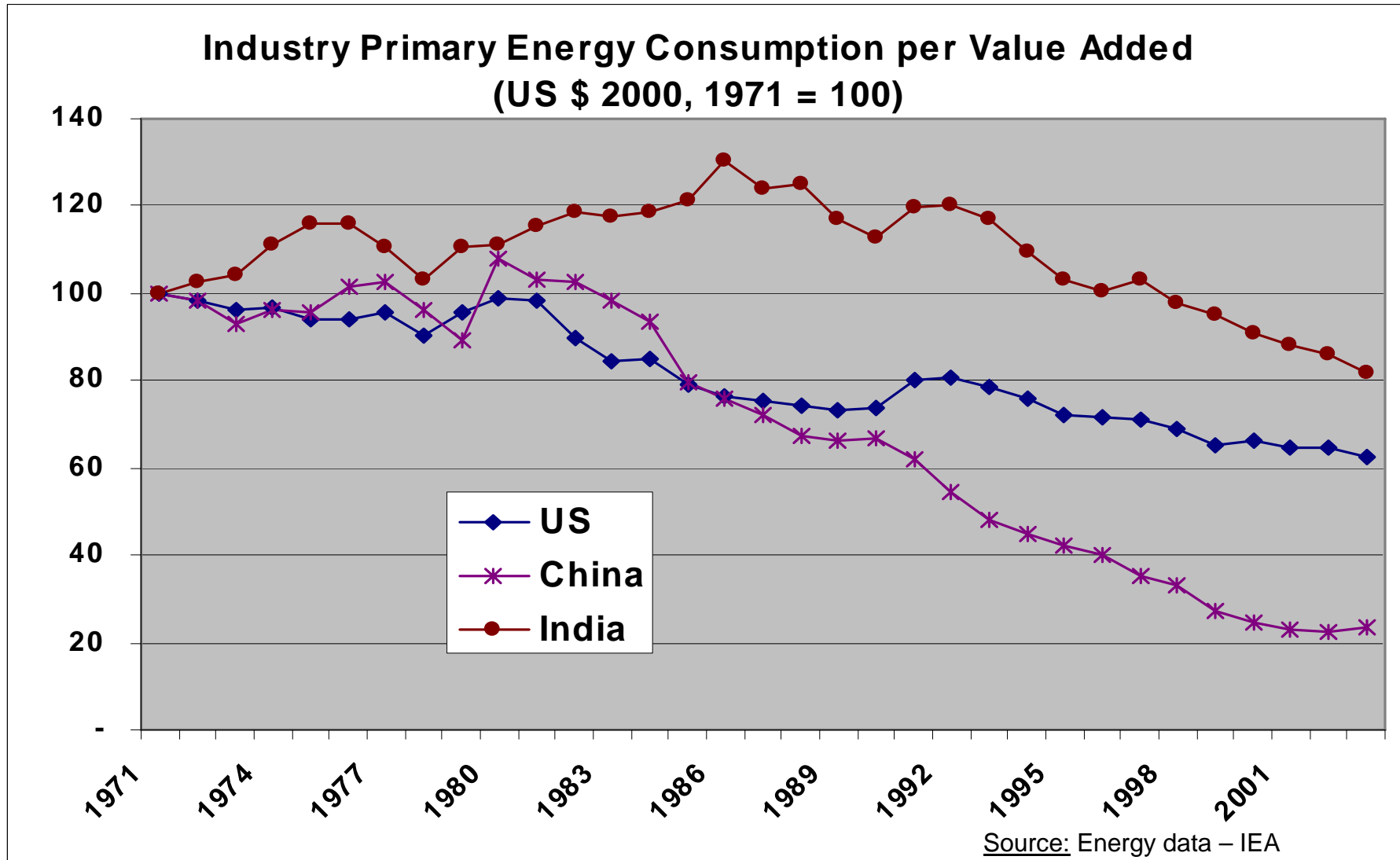


- Voluntary US programs, such as Energy Star – Works with manufacturers who can affix an easily visible label to products that meet Energy Star minimum specifications.
 - In 2004 the ENERGY STAR labeled products program saved over 60 billion kWh hours, reduced US emissions by 13 Mt CO₂, and saved consumers \$5.1 billion
 - International agreements in place to implement it in office and other products
- Building efficiency standards and codes -- In the US, the most important and widely used standards and codes are:
 - ASHRAE's Standard 90.1-2004 - Energy Standard for Buildings Except Low-Rise Residential Buildings
 - International Energy Efficiency Code developed by International Code Council
- Energy-efficient government purchasing strategy (energy efficient procurement in the public sector):
 - US government is the world's largest volume-buyer of energy-related products (\$10 billion/year)
 - US Federal Energy Management Program (FEMP) products are in the upper 25% of energy efficiency in their class
 - China, Korea, Japan, Mexico and several European Union countries implement similar programs



Industrial Sector Energy Efficiency Programs

Continued improvement in India's industrial energy intensity since mid-1980s



Industrial Production: Aluminum, Cement and Steel

India is a Relatively Smaller Producer Except in the Case of Cement



Country	Aluminum		Cement		Raw Steel	
	Thousand tonnes		Million tonnes		Million tonnes	
	2004		2005		2005	
China	6,670	22%	1,000	45%	333	31%
India	862	3%	130	6%	34	3%
US	2,516	8%	99.1	4%	92.4	8%
Other	19,752	66%	993	45%	631	58%
World Total	29,800	100%	2,222	100%	1,090	100%

Source: USGS, 2006

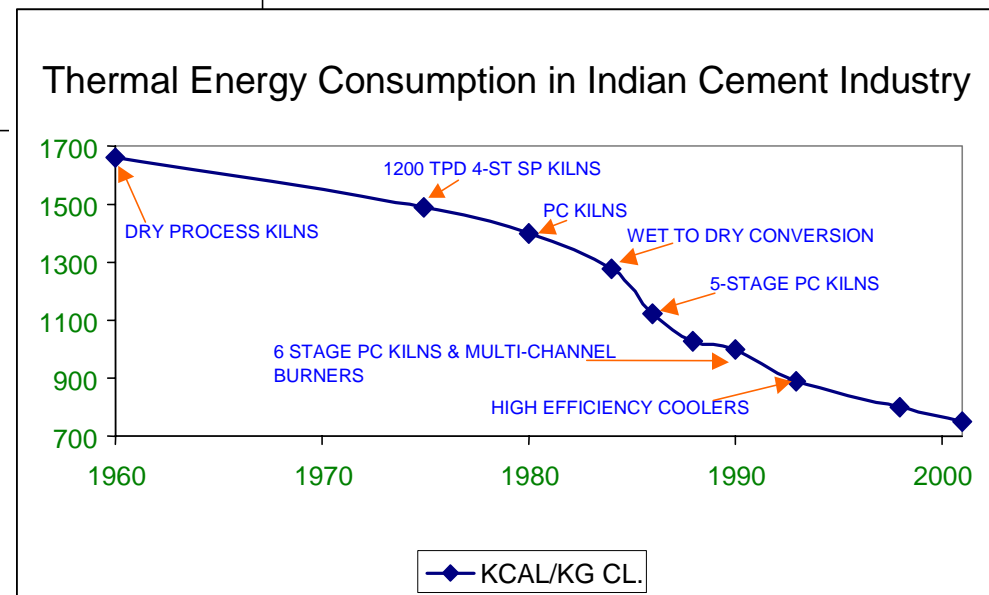
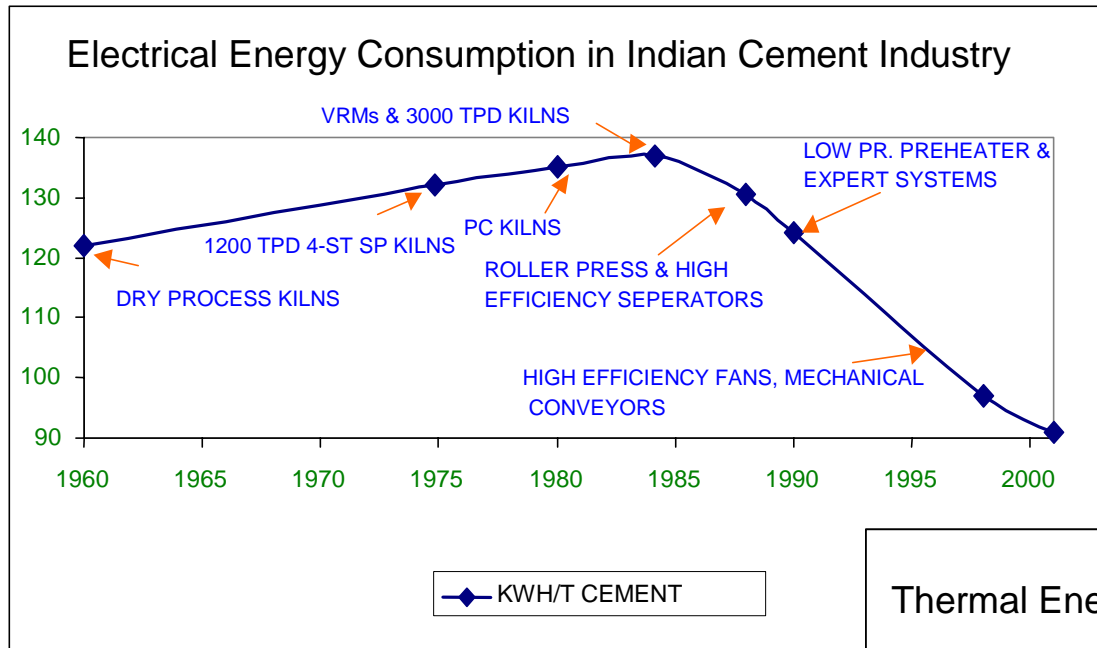
Estimated Energy Intensity Cement and Steel Manufacturing

Country	Cement	Steel
	(GJ / tonne cement)	(GJ / tonne cast steel)
China	5.7	23 -- 35
India	4.3	28 -- 32
US	5.4	20+ ? (MECS 94: 26)

Source: LBNL Estimate based on analysis of the industries in each country

- Need better benchmarking of industrial energy use which will open opportunities for voluntary energy efficiency programs

Cement Energy Intensity Trend, India

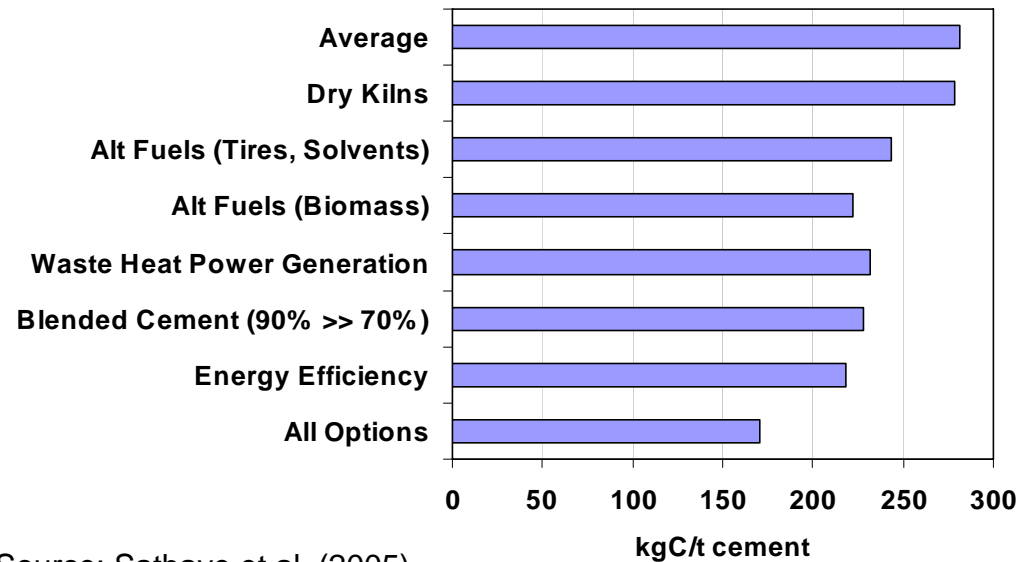
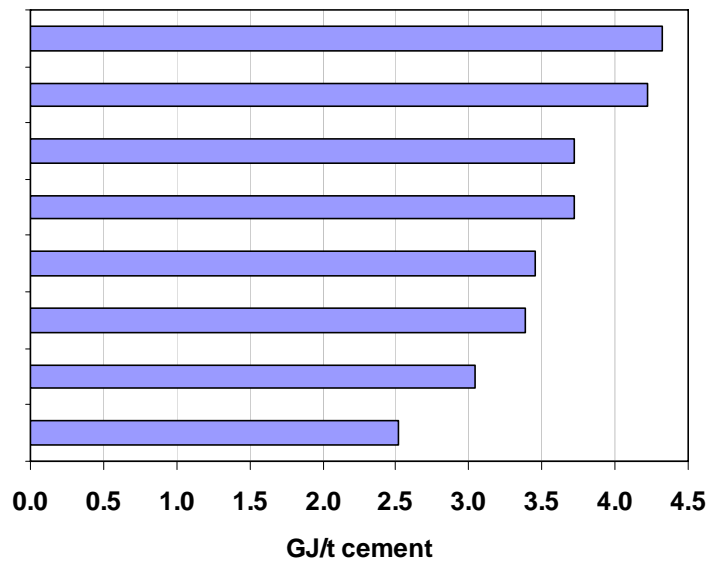


Source: Raina, 2002

Energy Efficiency in the Indian Cement Industry

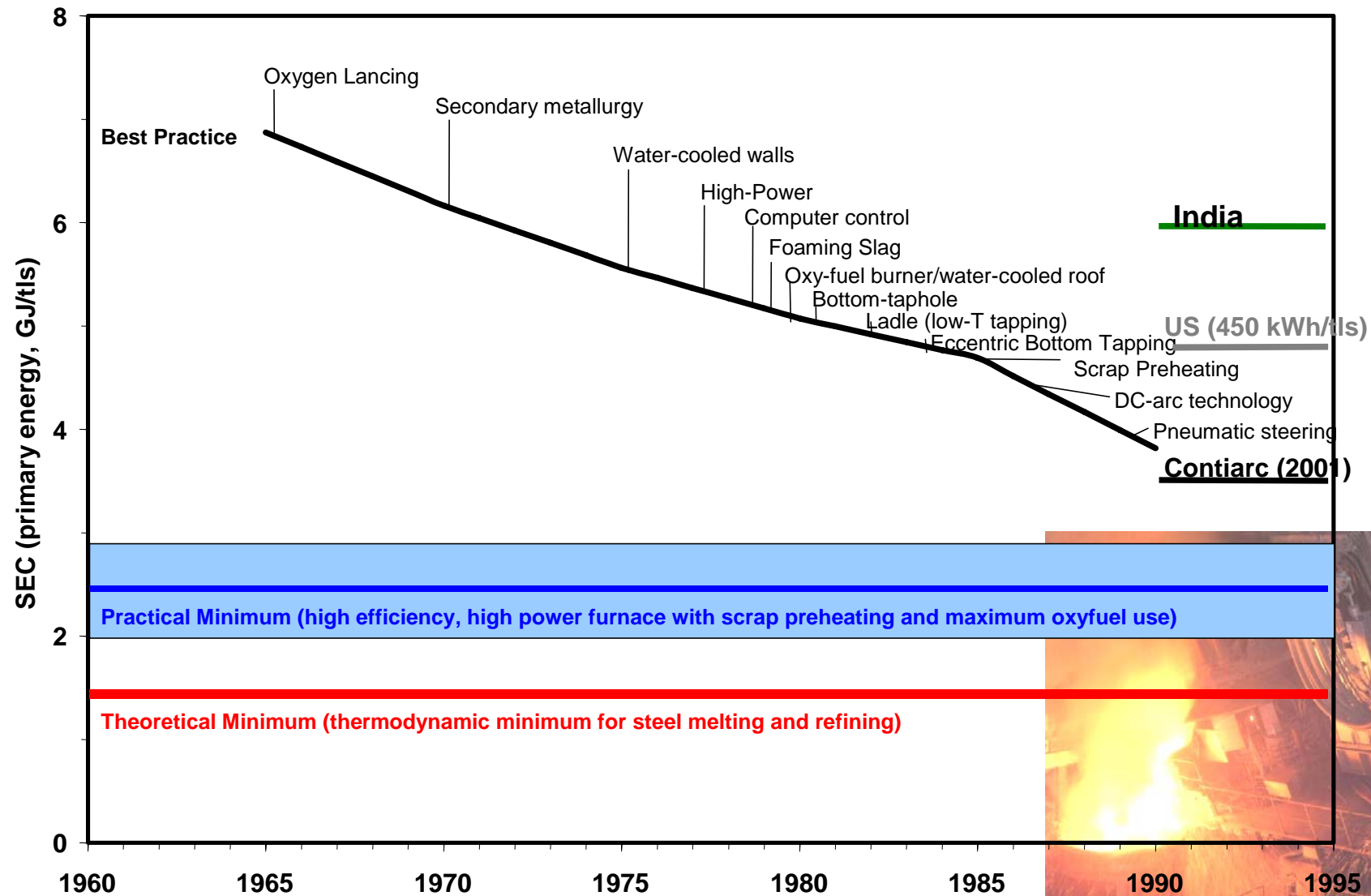


- Wide range in energy intensity in Indian cement industry
- Some of the most efficient plants in the world are in India
- Only 5% are inefficient wet kilns (vs. 18% in the U.S.)
- Energy savings and emission reduction possible through:
 - Improved energy efficiency
 - Increased blending of cement
 - Use of alternative fuels
 - Waste heat power generation



Source: Sathaye et al. (2005)

Energy Efficiency in the Steel Industry – Electric Arc Furnace



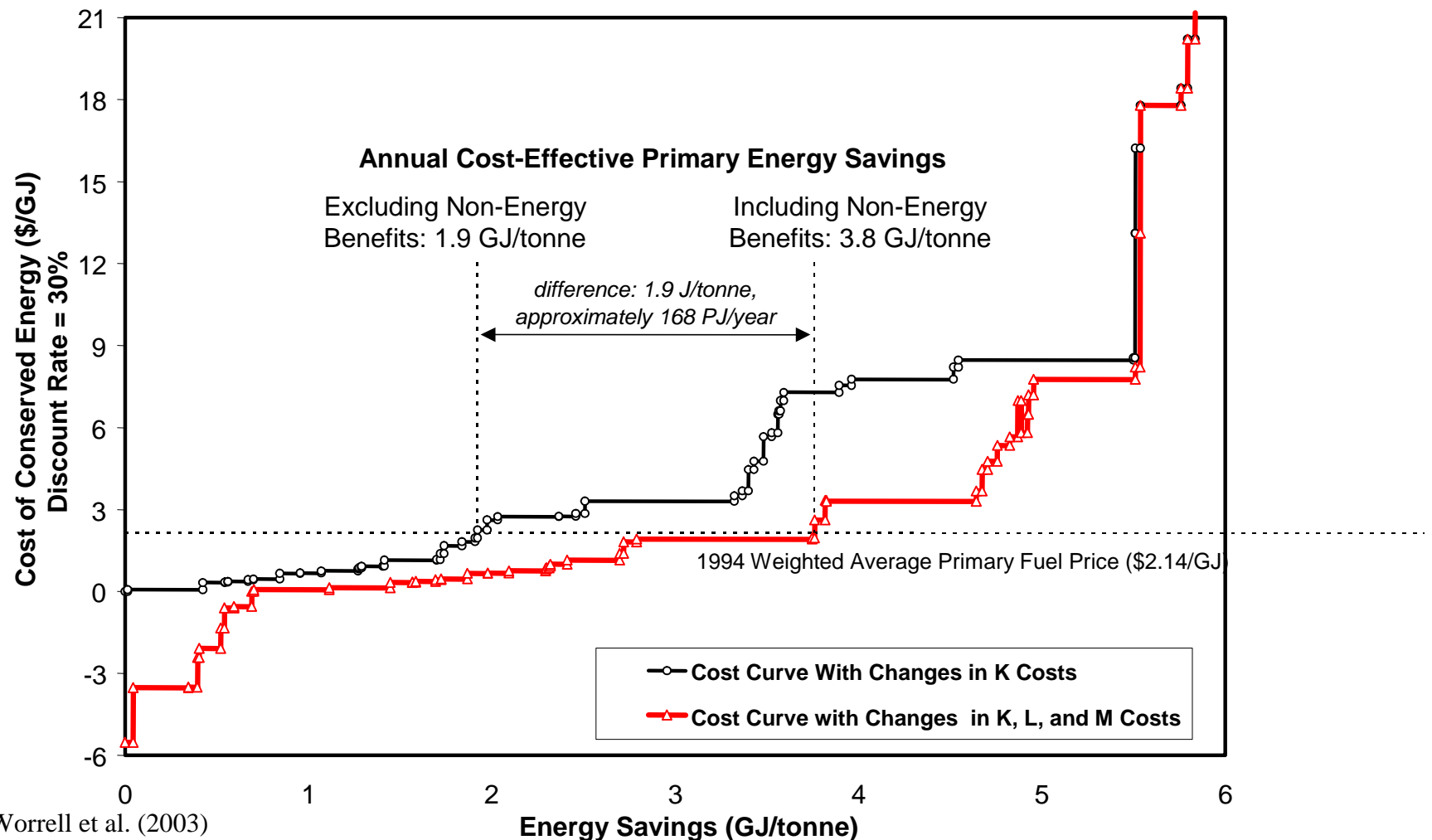
Source: LBNL Estimate

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US Steel Industry Supply Curves: Accounting for Changes in Capital, Labor, and Material Costs



Benefits double cost effective energy efficiency potential to 19%



Source: Worrell et al. (2003)

Effect of Accounting for Changes in K, L, and M Costs on Cost-Effectiveness and Ranking of Measures



	<i>With Energy (E) Benefit Only</i>			<i>With K,L,E, M Benefits</i>		
Measure	CCE	Rank	Cost-	CCE	Rank	Cost-
	(\$/GJ)	(of 47)	Effective?	(\$/GJ)	(of 47)	Effective?
Inj. of NG – 140	3.1	19	NO	-0.5	8	YES
Coal inj. – 225	3.9	22	NO	1	23	YES
Coal inj. – 130	4.4	23	NO	0.1	11	YES
DC-Arc furnace	5	26	NO	-1.3	6	YES
Process control	5.6	27	NO	-2.1	5	YES
Scrap preheating	6.7	31	NO	-0.6	7	YES
Thin slab casting	8.5	35	NO	1.9	27	YES
Hot charging	8.9	36	NO	5.3	35	NO
FUCHS furnace	12.7	37	NO	-3.5	3	YES
Adopt cont. cast	14.3	39	NO	-3.5	2	YES
Twin shell	16.6	40	NO	3.3	30	NO
Oxy-fuel burners	17.4	41	NO	-5.5	1	YES
Bottom stirring	20.5	45	NO	-2.4	4	YES
Foamy slag	30.1	46	NO	7.2	40	NO

NOTE: These cost of conserved energy (CCE) and cost-effectiveness calculations are based on a discount rate of 30% and an average primary energy price of \$2.14/GJ.

Industrial Energy Efficiency Policies, Programs, and Measures in Selected Industrialized Countries

US Program Examples:

- DOE Industrial Technologies Program
 - EPA Energy Star Program
 - State-level benchmarking and voluntary programs

[illegible]

Best Practice Steps for Buildings and Industry: Mandatory Standards and Labels, Voluntary Programs, Procurement, and Building Codes



- Seek commitment of the legislature and/or regulatory commission
- Assess the support of, and involve, key stakeholders
- Conduct thorough economic and environmental analysis
- Allow for longer time frames
 - Set annual and cumulative targets
- Important to select an effective entity to implement a program
- Designing, implementing and enforcing building codes requires a high level of expertise
 - Education and regular training of builders, supply companies, and code officials may lack is essential
- Start with low-cost, simple and well established programs
- Build in a monitoring plan and allow for third-party program evaluation and verification
- Maintain a functional database of project energy performance

Conclusions



Comprehensive Approach:

- All entities need to participate
- States have a strong role to play
- Energy efficiency portfolio standards (EEPS) for ministries and state entities

Targeting Energy Efficiency Opportunities

- Advancing EE in high priority areas
 - Separate short- and long-term options
- Combine Energy Efficient Procurement with Technology-Specific Building Retrofits
- Triggering EE Market Transformation

Conclusions



Financing and capacity building:

- Improving a borrower's credit worthiness may be particularly important when lending to small and medium scale enterprises and municipalities.
- Carbon finance can play an important role
- Energy service companies (ESCOs)
- Expand best practices within and across industry and buildings sectors

Data, Analysis and Planning:

- Regularize data collection and analysis
- Monitoring, evaluation and verification
- Setting up centers of excellence in energy efficiency

International Cooperation

- Fostering cooperation between US and India requires that entities with similar energy efficiency functions exist in both countries



Thank you

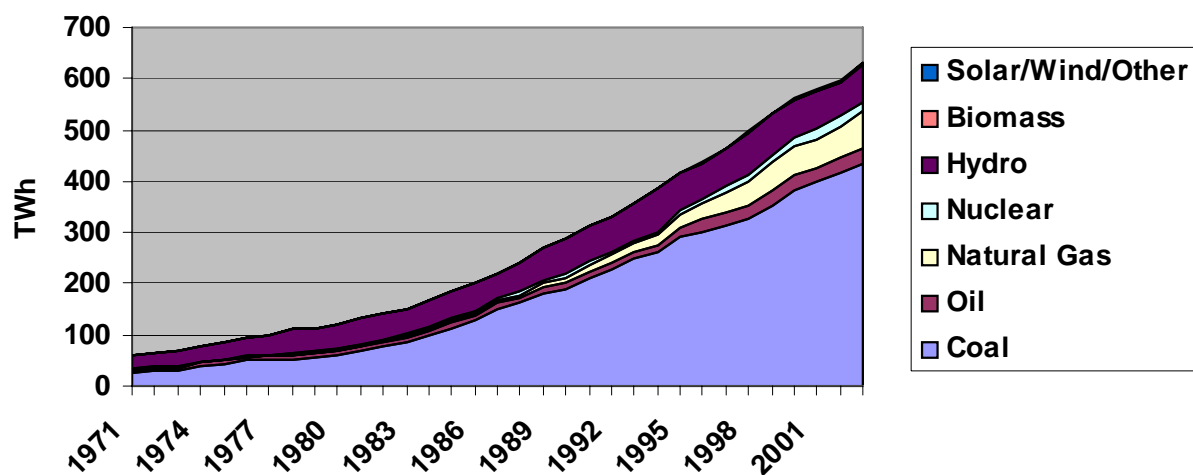
Please check these websites for
LBNL India publications and activities and links

<http://ies.lbl.gov/iespubs/indiapubs.html>

<http://www.dc.lbl.gov/india/>



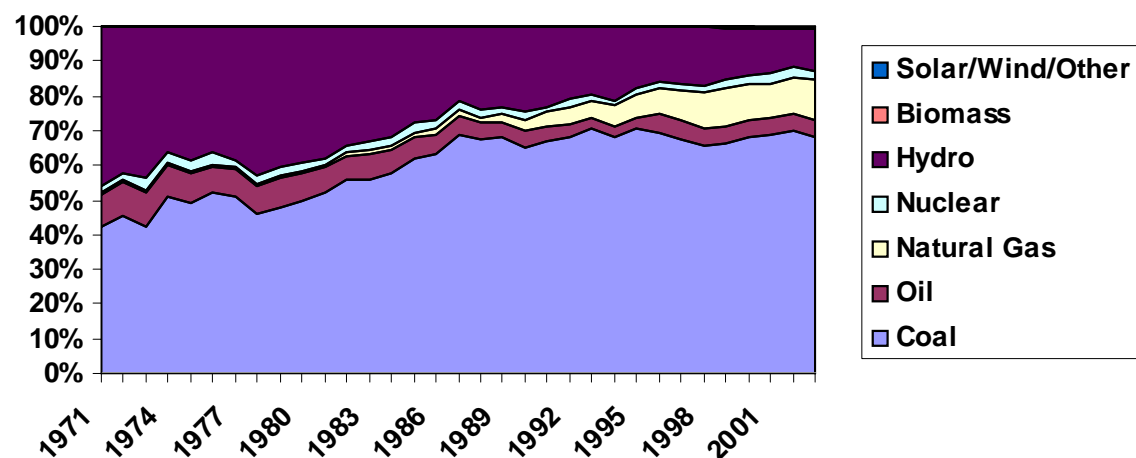
Electricity Generation by Source



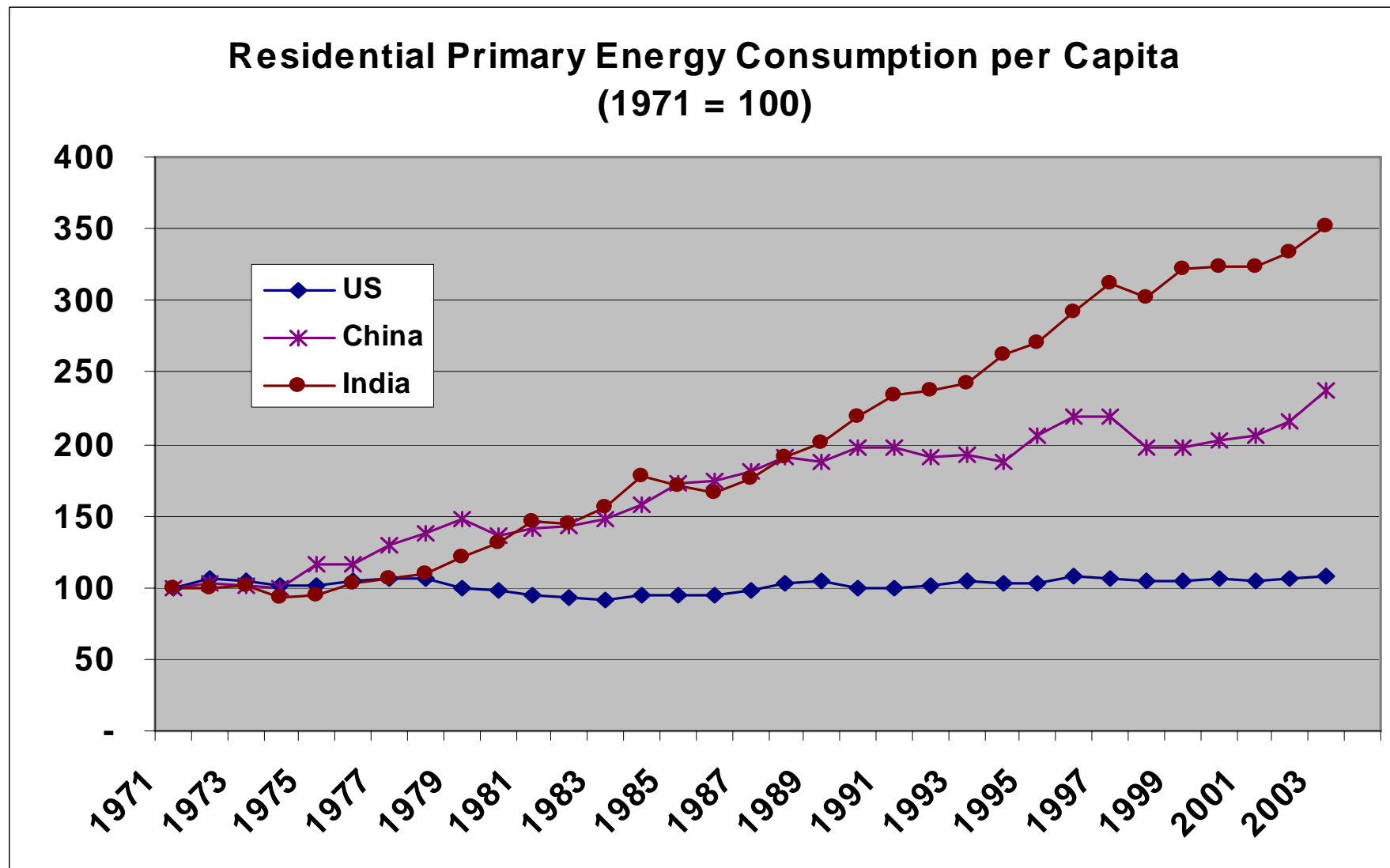
Electricity Generation Capacity, India (2004-05)

	Generation Capacity	
	(MW)	(%)
Coal	68,434	55.5
Natural Gas	12,430	10.0
Oil	1,201	0.9
Hydro	32,135	26.0
Nuclear	3,310	2.7
Other	6,158	4.9
Total	123,668	100
Captive (>1 MW)	7,195	23.8
Captive (< 1 MW)	23,000	76.2
Total Captive	30,195	100

Shares



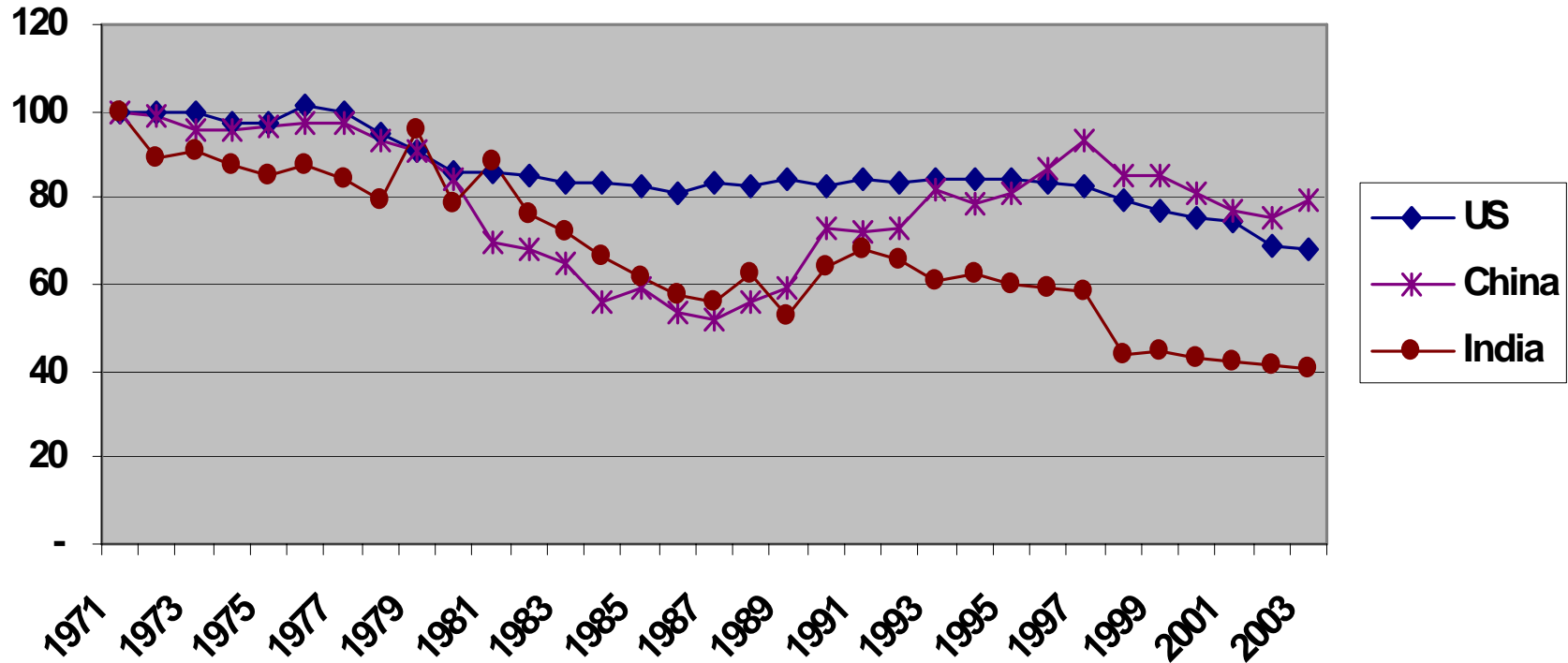
Conversion to modern fuels adds to increase in India's household energy use per capita



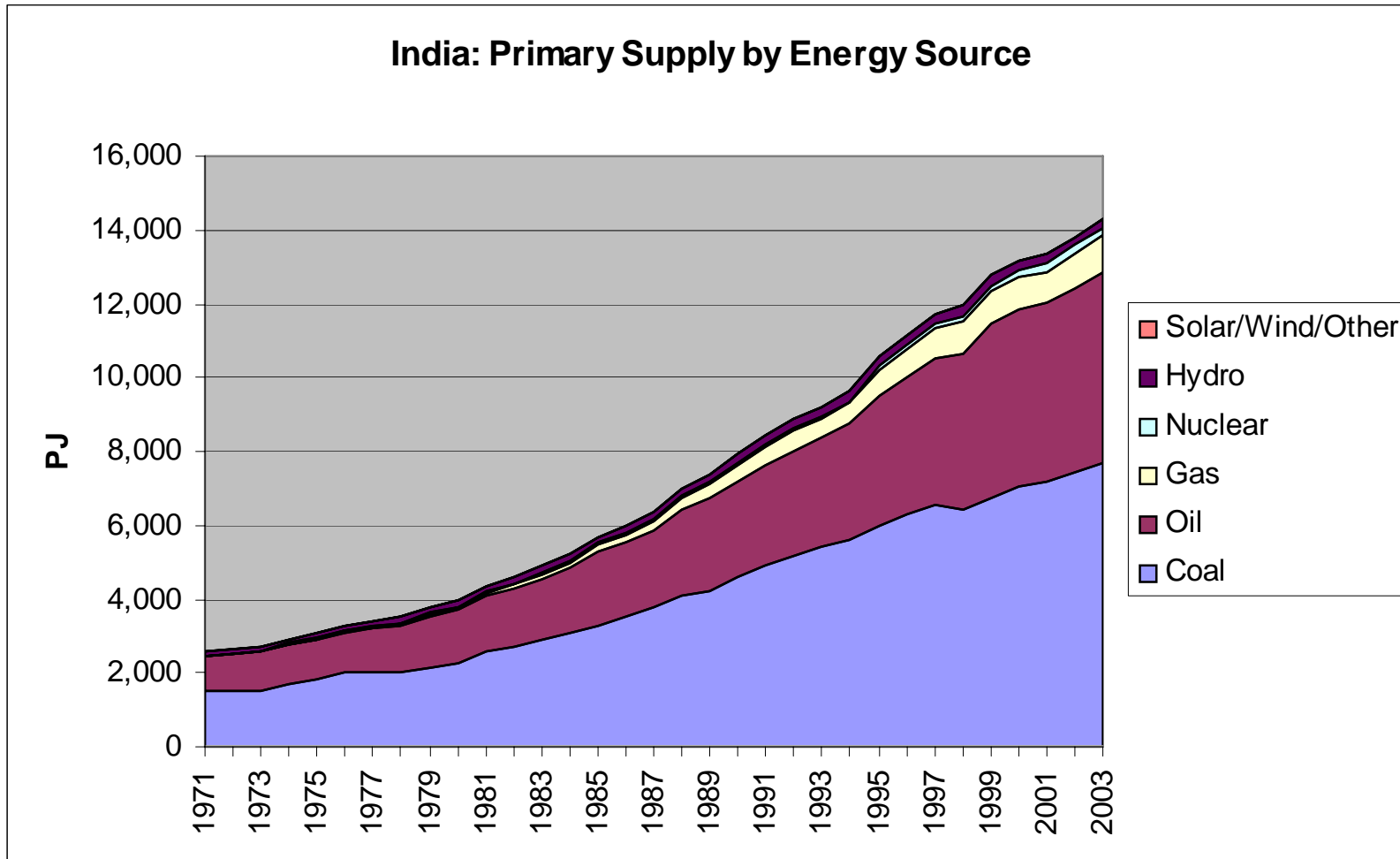
Rapid decline in service sector energy intensity due to fast growth in services value added



Services Primary Energy Consumption per value Added
(1971 = 100)

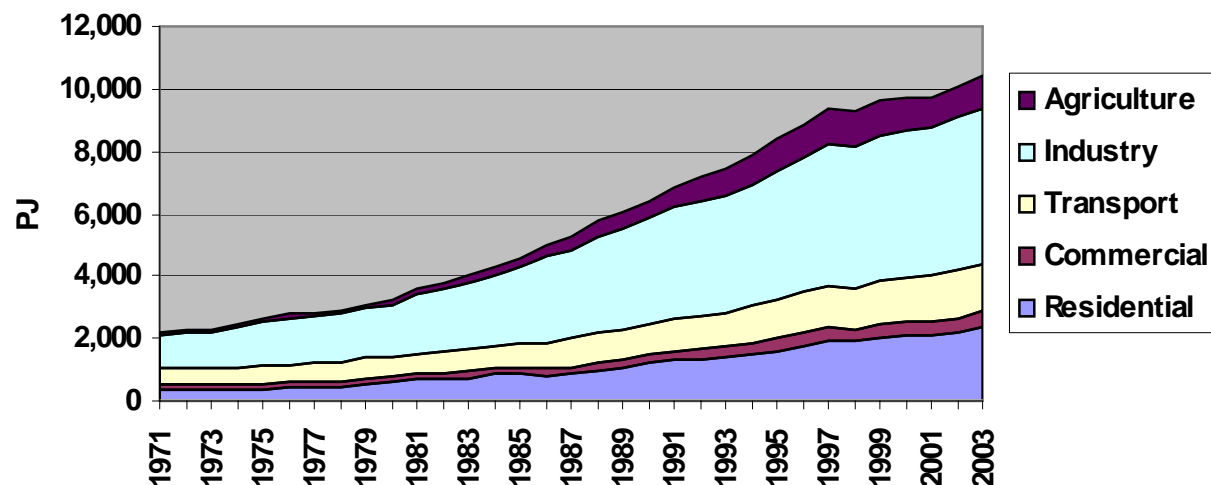


Coal continues to dominate energy mix, although natural gas share has increased

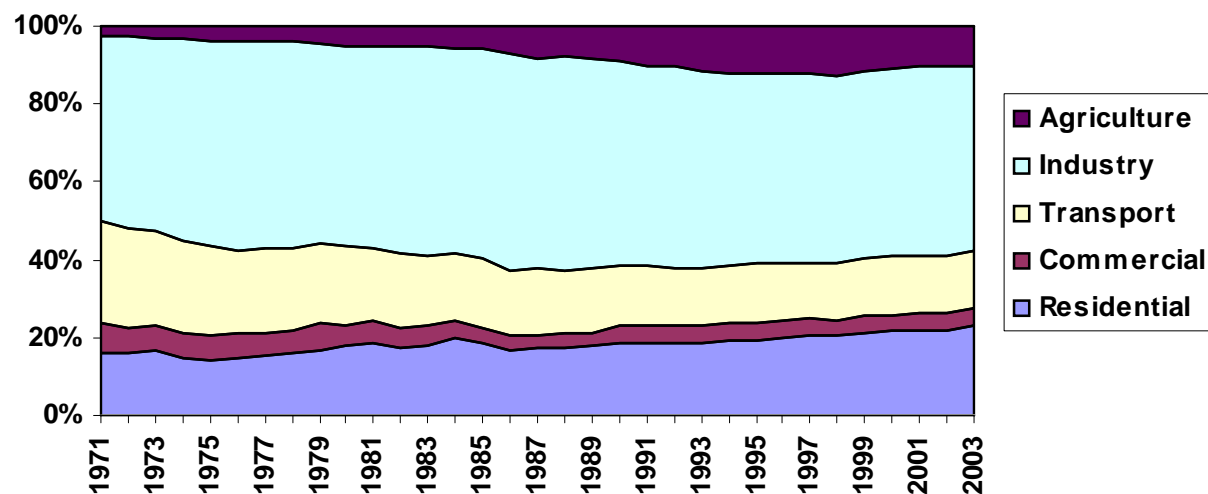


Source: Energy data – IEA

Primary Energy Consumption, India (Excl. traditional biomass)



Sectoral Shares



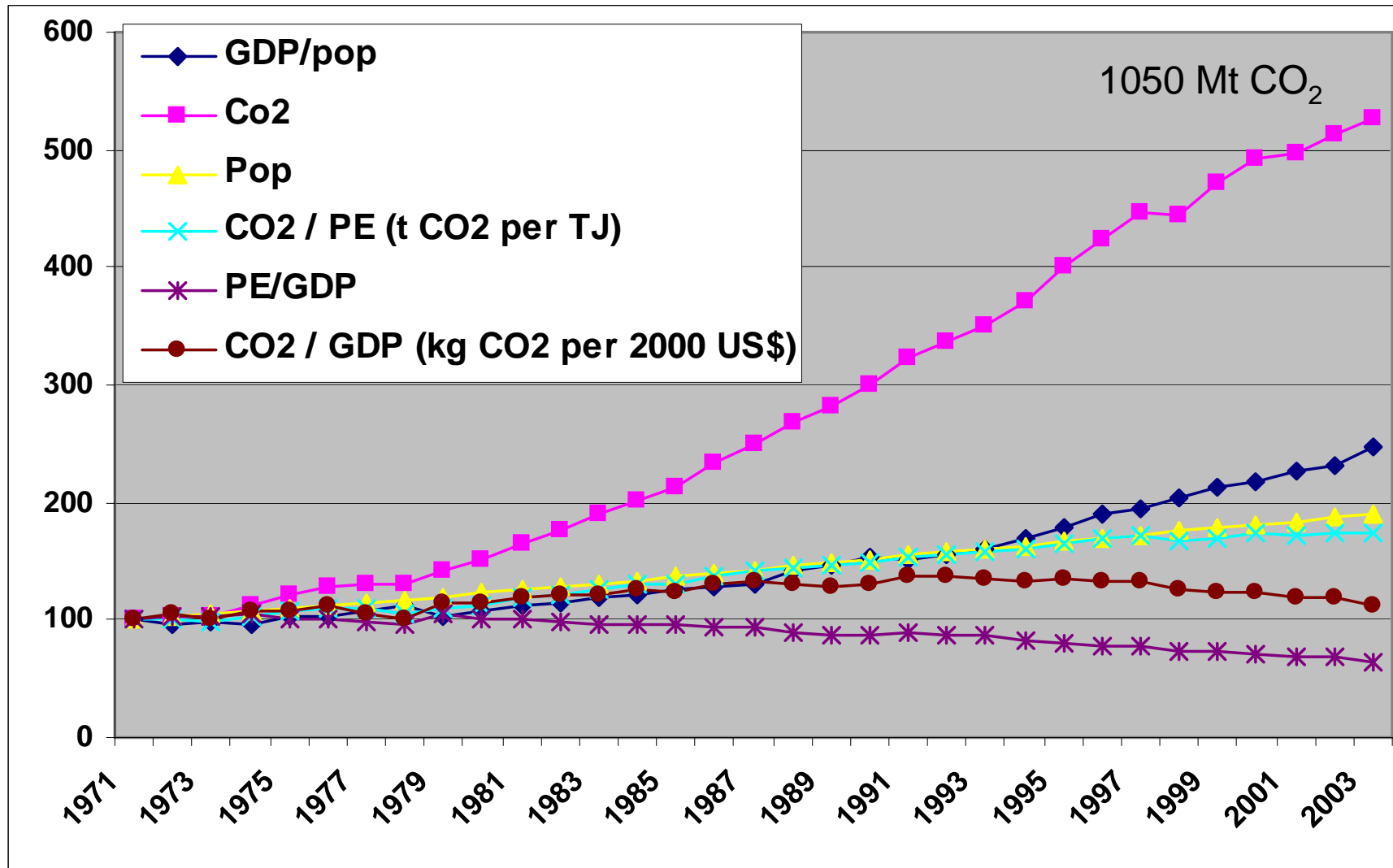
Increased Share of Agriculture and Residential and Commercial Energy Use:

- Electricity subsidized to both sectors
- 25% of state fiscal deficit in many states
- Subsidy is about \$2 billion annually

Source:

Energy data – IEA

Decomposing India CO₂ Emissions: Economic and population growth more than offset recent decline in CO₂ emissions intensity



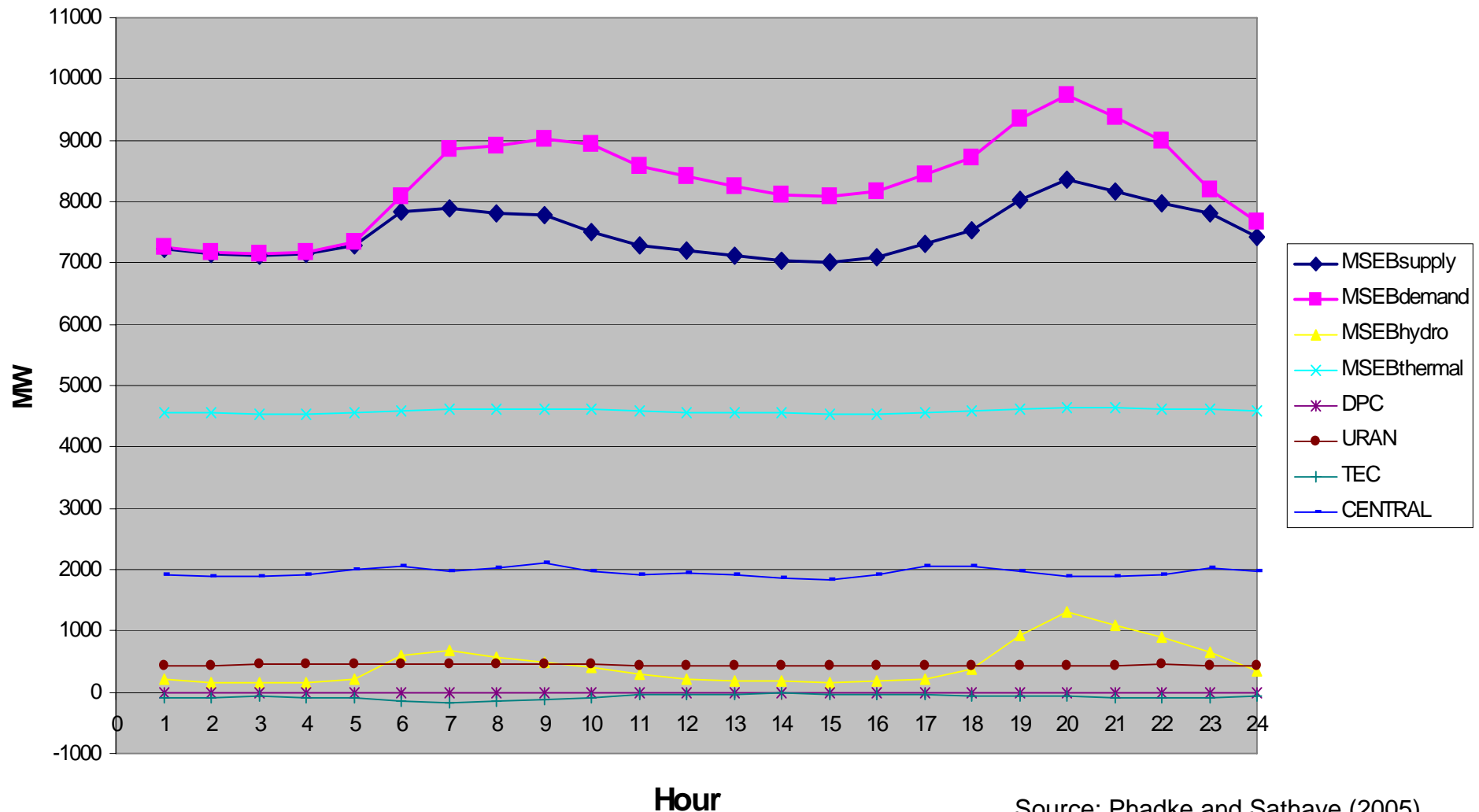
Source: Energy data – IEA; Economic data – World Bank

India Electricity Sector: Background Summary



- Consumption per capita of 400 kWh in 2004-05, assuming 25% technical T&D loss; US consumption per capita – 13,000 kWh
- India sectoral consumption shares in 2004-05:
 - Industrial – 35.6% -- Average tariff about 7 cents per kWh
 - Residential 24.8% -- Subsidized – average tariff about 6 cents/kWh
 - Commercial 8.1% -- Maximum tariff, about 9 cents per kWh
 - Agricultural – 22.9% -- Heavily subsidized – average tariff < 1 cent/kWh
- Continued deficit supply in 2004-05:
 - Peak power deficit 11.6%
 - Energy deficit 8 %
- Severe transmission and distribution (T&D) loss
 - About 50% in 2004-05 aggregate technical and commercial loss (AT&C)
 - Assuming 25% is technical loss -- 100 billion kWh or about \$6 billion a year
- Five year plan targets have not been met:
 - Against the 9th Plan (1997-'02) target of 40,245 MW new capacity, addition was about 21,000 MW
 - Private sector target: 17,589 MW vs. a realized addition of 6,735 MW
 - 10th plan (2002-'07) target 41,010 MW, revised down to 36,956 MW, commissioned: 13,416 MW
 - Deficits likely to continue in the near term

Maharashtra State Electricity Board (MSEB) Capacity Deficit – Annual average (2002-03) (7836 GWh load shedding over 20 hours a day; 1376 MW average evening peak load shedding)



Source: Phadke and Sathaye (2005)

Primary Energy Supply* / GDP (Indexed to 1971)

